A 6-year trends analysis of infections after revision total hip arthroplasty

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Background: Substantial efforts have been made to reduce the risk of infection after total hip arthroplasty (THA), including pre-operative patient optimization, skin preparation with alcohol-based solutions, perioperative antibiotics, and minimizing wound drainage with novel sutures and dressings. While these approaches have been effective in primary THA, their effects on revision THA to improve surgical site infection (SSI) rates are less clear. Therefore, the purpose of this study was to identify the annual rates and trends of: (I) overall; (II) deep; and (III) superficial SSIs following revision THA using the most recent results (2011 to 2016) from a large, nationwide database.

Methods: The National Surgical Quality Improvement Program (NSQIP) database was queried for all revision THA cases (CPT code 27134) between 2011 and 2016, yielding 8,562 cases. A steady increase in the total number of revision THA cases was observed from 2011 to 2016 (750 *vs.* 1,951, 260%). Cases with reported superficial and/or deep SSI were analyzed separately and then combined to evaluate overall SSI rates. The infection incidence for each year was calculated. After an overall 6-year correlation and trends analysis, univariate analysis was performed to compare the most recent year, 2016, with each of the preceding 5 years. Additionally, percent differences between 2016 and each previous year were calculated to evaluate rate changes. Pearson correlation coefficients and chi-squared tests were used to determine correlation and statistical significance which was maintained at a P value less than 0.05.

Results: There were 217 cases out of 8,562 (2.53% of all cases) complicated by any SSI. Overall, there was an inverse correlation between combined SSI rate and year, however, this was not statistically significant (P>0.05). The lowest incidence was in 2016 (n=41, 2.10%), while the highest incidence was in 2014 (n=45, 2.86%). The combined SSI rate in 2016 decreased by 22% when compared to 2015 (2.10% *vs.* 2.69%, P>0.05). A larger, 27% decrease in rate was found between 2016 and 2014 (2.10% *vs.* 2.86%, P>0.05). For deep SSI, there was an inverse correlation between rate and year of surgery, however, this was not statistically significant (P>0.05). The deep SSI incidence over the 5 years was 1.38% (118 out of 8,562 cases). There was a 35% decrease in deep SSI rate from 2016 to 2015 (0.92% *vs.* 1.43%, P>0.05). A larger, 53% decrease, was seen between 2016 and 2014 (0.92% *vs.* 1.04%, P<0.01). For superficial SSI, there was an inverse correlation between rate and year, however, this was not statistically significant (P>0.05). In this 6-year period, 99 cases out of 8,562 were complicated by a superficial SSI; an incidence of 1.16%. The lowest incidence occurred in 2014 (n=14, 0.89%), while 2012 had the highest incidence (n=17, 1.61%). The rate in 2016 decreased by 6% when compared to 2015 (1.18% *vs.* 1.07%, P>0.05). A larger, 27% decrease in rate was observed between 2016 and 2012 (1.18% *vs.* 1.61%, P>0.05).

Conclusions: Revision total hip arthroplasties exhibited a trend towards decreasing overall SSI nationwide between 2011 and 2016. Deep SSI rates had marked improvements, specifically between 2014 and 2016. This trend indicates some benefit from pre- and post-operative infection preventative strategies, but importantly, indicates continued room for improvement. Due to the potentially devastating complications associated with infection in revision THAs, further research is required to identify revision-specific strategies to lower the rates of SSIs.

Keywords: Infection; surgical site infection (SSI); PJI; revision total hip arthroplasty (revision THA); trends

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Introduction

Although uncommon, surgical site infections (SSIs) are severe complications following revision total hip arthroplasty (THA), and can lead to increased morbidity and mortality as well as the need for additional surgeries. Revision surgeries in particular are of concern for infection, as an extensive surgical approach can impose substantial insult to the surrounding soft tissue envelope, creating a greater inherent risk for SSIs than primary procedures. Because of the post-operative consequences of SSIs, a number of preventive infection measures have been adopted over the years, such as prophylactic antibiotic therapy, pre-operative patient optimization, operating room filtration systems, and many others (1-8). Intra-operative strategies include irrigation, intra-wound powdered antibiotics, and newer suture types and techniques. To protect the wound, different dressing types, such as negative pressure wound therapy, has been shown to significantly reduce SSI risks [relative risk 0.43, 95% confidence interval (CI): 0.32 to 0.57, P<0.0001] (9). Although a number of different SSI preventative strategies have been adopted, there is still conflicting evidence regarding THA infection trends, particularly in revision cases (10).

The current literature reports infection rates after primary THA to be between 0.2% and 0.7%. However, that number varies substantially between 0.95% and 22% for revision THAs (10,11). Phillips *et al.* investigated Medicare claims data for revision THA between 1995 and 1996 and found infections rates to be 1.1% (12). In more recent data from 2000 to 2011, Everhart *et al.* investigated risk factors for infection in 652 revision THA and found the infection incidence to be 6.2% (13). Due to these inconsistencies, the importance to track our progress in fighting infections, and the need for more up-to-date analyses, it is critical to continuously assess nationwide infection trends.

Although the current literature shows an increasing incidence of infection after revision THA, the data is varied and not current. Due to the increased mortality associated with infections after revision THA, we need to re-evaluate if our current SSI prevention strategies have slowed down the increasing trend of infection. Furthermore, although specific measures and their direct effects on infection incidences have often been investigated, the collective influence of all these efforts over an extended period of time has not been well-assessed in the literature. Therefore, the question than remains, have we been able to slow down the increasing trend of SSI rates in revision THA? To answer this, we tracked the annual rates and trends of: (I) overall; (II) deep; and (III) superficial SSIs following revision THA.

Methods

Data source

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database prospectively collects data from millions from community and academic centers across the United States. Using Current Procedural Terminology (CPT) code 27134, patients who underwent revision THAs were identified from the database from January 1, 2011 to December 31, 2016. The query results in 8,562 cases, which were initially stratified according to the year of surgery. A 260% increase in the annual number of revision THA cases performed was observed from 2011 (750 cases) to 2016 (1,951 cases; *Figure 1*). Because the data was de-identified and publicly available, this study was deemed exempt by the Institutional Review Board.

Outcomes of interest

SSIs that occurred within 30 post-operative days for

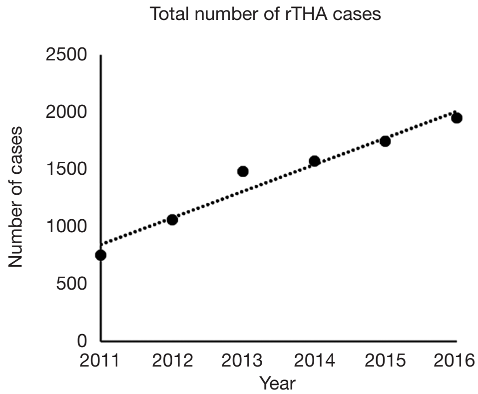

Figure 1 Number of revision total hip arthroplasties per year.

Table 1 Annual incidence of surgical site infections (SSIs)

Year	Total number of superficial SSI (%)	Total number of deep SSI (%)	Total number of combined SSI (%)
2011	8 (1.07)	9 (1.20)	17 (2.27)
2012	17 (1.61)	11 (1.04)	28 (2.64)
2013	15 (1.01)	24 (1.62)	39 (2.63)
2014	14 (0.89)	31 (1.97)	45 (2.86)
2015	22 (1.26)	25 (1.43)	47 (2.69)
2016	23 (1.18)	18 (0.92)	41 (2.10)
Total	99 (1.16)	118 (1.38)	217 (2.53)

each patient were extracted from the database. SSIs were classified as either deep or superficial incisional SSIs. Deep SSIs included those with purulent drainage, or a deep incision that dehisces, or an infection found on reoperation. Superficial SSIs were identified by swelling or erythema, which required less aggressive treatment. An overall deep plus superficial SSI rate was also analyzed.

Data analyses

For each year, overall, deep, and superficial SSI incidences were calculated. Correlative analyses associating the year of surgery and infection incidence were determined with Pearson correlation coefficients. Annual infection incidences for each type of SSI were plotted against the year of surgery for trends analyses.

The infection incidence of the most recent year, 2016, was compared to the preceding 4 years utilizing univariate analysis with Pearson's chi-squared tests. Percent differences between infection rates in 2016 and infection rates of each previous year were also calculated to evaluate rate changes. Data analyses were conducted using SPSS version 22.0 for Windows (IBM, Armonk, New York, USA) and statistical significance was maintained at a P value of less than 0.05.

Results

Overall SSI

Over the 6-year study period, a total of 217 (2.53%) out of 8,562 revision THA cases were complicated by any SSI. The lowest incidence of overall SSIs was in the most recent year tabulated, 2016 (2.10%), while the highest incidence was in the earliest year, 2014 (2.86%; *Table 1*).

An inverse correlation between combined SSI rate and year was noted, however, this was not found to be statistically significant (P>0.05) (*Figure 2*).

The combined SSI rate in 2016 decreased by 22% when compared to 2015 (2.10% *vs.* 2.69%, P>0.05). A larger, 27% decrease in rate was found between 2016 and 2014 (2.10% *vs.* 2.86%, P>0.05) (*Table 2*).

Deep SSIs

For deep SSIs, the incidence over 5 years was 1.38% (118 out of 8,562 cases). There was an inverse correlation between rate and year of surgery, however, this was not found to be significant (P>0.05; *Figure 2*).

There was a 35% decrease in deep SSI rate from 2015 to 2016 (1.43% *vs.* 0.92%, P>0.05). A larger, 53% decrease was seen between 2016 and 2014 (0.92% *vs.* 1.04%, P<0.01) (*Table 3*).

Superficial SSIs

In this 6-year period, 99 cases out of 8,562 were complicated by a superficial SSI; an incidence of 1.16%. The lowest superficial SSI incidence occurred in 2014 (n=14, 0.89%), while 2012 had the highest incidence (n=17, 1.61%) (*Table 1*).

There was an inverse correlation between rate and year, however, this was not statistically significant (P>0.05).

The rate in 2016 decreased by 6% when compared to 2015 (1.18% *vs.* 1.26%, P>0.05). A larger, 27% decrease in rate was observed between 2016 and 2012 (1.18% *vs.* 1.07%, P>0.05) (*Table 4*).

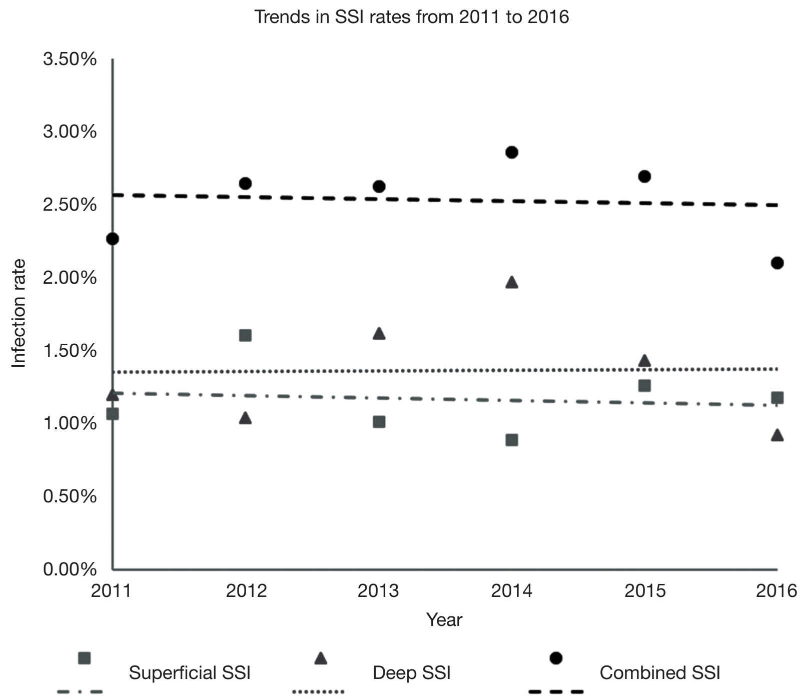

Figure 2 Trends in SSI rates after revision total hip arthroplasty (THA) from 2011 to 2016. SSI, surgical site infection.

Table 2 Overall surgical site infection rate in 2016 compared to preceding 4 years

Year	Overall SSI cases, n (%)	Percent difference (%)	P value
2016/2015	41 (2.10)/47 (2.69)	22	0.241[c]
2016/2014	41 (2.10)/45 (2.86)	27	0.146[c]
2016/2013	41 (2.10)/39 (2.63)	20	0.311[c]
2016/2012	41 (2.10)/28 (2.64)	21	0.342[c]
2016/2011	41 (2.10)/17 (2.27)	7	0.791[c]

[c], Pearson's chi-square test.

Table 3 Deep surgical site infection rates in 2016 compared to the preceding 4 years

Year	Deep SSI cases, n (%)	Percent difference (%)	P value
2016/2015	18 (0.92)/25 (1.43)	36	0.149[c]
2016/2014	18 (0.92)/11 (1.04)	53	0.008[c]
2016/2013	18 (0.92)/31 (1.97)	43	0.066[c]
2016/2012	18 (0.92)/9 (1.20)	11	0.755[c]
2016/2011	18 (0.92)/24 (1.62)	23	0.421[c]

[c], Pearson's chi-square test.

Table 4 Superficial surgical site infection rates in 2016 compared to the preceding 4 years

Year	Superficial SSI cases, n (%)	Percent difference (%)	P value
2016/2015	23 (1.18)/22 (1.26)	6	0.822[c]
2016/2014	23 (1.18)/17 (1.61)	32	0.404[c]
2016/2013	23 (1.18)/14 (0.89)	16	0.641[c]
2016/2012	23 (1.18)/8 (1.07)	27	0.329[c]
2016/2011	23 (1.18)/15 (1.01)	10	0.806[c]

[c], Pearson's chi-square test.

Discussion

Poor functional outcomes and increased rates of mortality after infection for total joint arthroplasty have led to a wide range of infection prevention measures which have now been the new standard over the past several years. Despite the fact that revision arthroplasty surgery is a risk within itself for SSI, there is limited literature evaluating the annual rates of infections after these procedures. Therefore, a newer, up-to-date analysis was needed to assess infection trends. The results from this study identified a decreasing trend both superficial and deep SSIs after revision THAs. For deep SSIs in particular, a significant, 53%, decrease (0.92% versus 1.04%, P<0.01) was noted from 2014 to 2016.

There are some limitations to this study. Because the data evaluated was collected from a number of different centers throughout the country, it was not possible to ensure the same infection classifications and criteria were used at each site. Nevertheless, because infections are relatively rare post-operative complications, it is necessary to use a large database such as NSQIP. Furthermore, although there is potential for data collection heterogeneity, because the data was collected from a large sampling of hospitals, it provides greater, nationwide generalizability than institution or region specific data. Additionally, the data analyzed included up to 30 post-operative day, so there is a potential for missed infections that occurred outside of this window. Nevertheless, to the best of the author's knowledge, this study provides the most up-to-date trends analyses in infections after revision THA.

Some of the current evidence supports the decreasing trend of infection after revision THA. Pugely *et al.* reviewed 1,036 revision THAs in the years prior to our study, 2005 to 2010, using the same NSQIP database. They found a higher incidence of SSI, 2.9% and 1.7% for both overall and deep respectively (5). Additionally, Rasouli *et al.* evaluated SSIs using a Nationwide Inpatient sample database from 2002 to 2010 and found that over this time period, logistic regression showed that SSI rates declined with year. Furthermore, the authors of that study also evaluated infection trends in primary THA, and also found decreasing rates of overall, deep and, superficial infections.

In contrast to our study, Wolf *et al.* found increasing rates of complications following revision THA. In 337,874 revision THAs investigated between 1991 and 2008 using the United States Medicare Beneficiaries database, the group discovered a >20% increase in the readmission rate after revision THA. Over this time period, there was a steady increase in infection rates of 1.1%, 1.3%, 1.6%, 1.8%, 2.1%, and 2.9% respectively (P<0.0001) (14).

Some studies have identified important risk factors that could increase the rate of infection after revision THA. Kosashvili *et al.* reviewed 749 revision THAs at a mean follow up of 13.2±5.9 years, and found that infection occurred in 2.14% of these revisions. Interestingly, there was a direct and significant correlation between the number of revision THAs and the incidences of infection. Compared to a single revision surgery, infection rates increased by 42%, 84% and 480.7% after a 2nd 3rd and 4th or greater operation (15).

Conclusions

Revision total hip arthroplasties exhibited a trend, although without statistical significance, of decreasing overall SSIs nationwide between 2011 and 2016. Deep SSI rates specifically had marked improvement between 2014 and 2016. This trend indicates some benefit from pre- and post-operative infection prevention strategies, but importantly indicates continued need for improvement. Due to the potentially devastating complications associated with infection in revision THAs, further research is necessary to identify revision-specific strategies to lower the rates of SSIs.

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None.

Footnote

Conflicts of Interest: SM Kurtz: Celanese, Ceramtec, Elsevier, Ferring Pharmaceuticals, Exponent, Invibio, Simplify Medical, Stelkast, Kyocera Medical, Wright Medical Technology, Lima Corporate, Stryker, Zimmer; CA Higuera: 3M, American Association of Hip and Knee Surgeons, *American Journal of Orthopedics*, CD Diagnostics, Cempra, Cymedica, *Journal of Hip Surgery*, *Journal of Knee Surgery*, KCI, Mid-American Orthopaedic Association, Musculoskeletal Infection Society, Myoscience, National Quality Forum, OREF, Orthofix, Inc., Pacira, Stryker, TenNor Therapeutics Limited, The Academy of Medicine of Cleveland & Northern Ohio (AMCNO), Zimmer; MA Mont: AAOS, Cymedica, DJ Orthopaedics, Johnson & Johnson, *Journal of Arthroplasty*, *Journal of Knee Surgery*, Microport, National Institutes of Health (NIAMS & NICHD), Ongoing Care Solutions, Orthopedics, Orthosensor, Pacira, Peerwell, Performance Dynamics Inc, Sage, Stryker: IP royalties, Surgical Technologies International, Kolon TissueGene. The other authors have no conflicts of interest to declare.

Ethical Statement: This study was deemed exempt by the Institutional Review Board.

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